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Subtracting difference: troubling transitions from GCSE to AS-level mathematics

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This article provides an approach to understanding the widely acknowledged difficulties experienced by young people in the transition from pre-16 to post-16 mathematics. Most approaches to understanding the disenchantment with and drop-out from AS-level mathematics focus on curriculum and assessment. In contrast, this article looks at the role of relationships, taking a psychosocial approach. It draws on data from a three-year qualitative study into why young people choose mathematics. It argues that educational practitioners and policy makers are responding to stories of failure and drop-out by excluding more people from access to mathematics. There is less and less room for difference within our mathematics classrooms. This happens because of the ways that discourses around mathematics fix how we think of the subject, who can learn it and what kind of relationships are possible between learners and mathematics. Instead the article argues for unfixing these through policies and pedagogies of difference.

Introduction

This article is an exploration of the problematic transition from GCSE to AS-level mathematics.[1] This has always been a difficult transition and was one that troubled me during the eight years that I taught A-level mathematics. However, the introduction of Curriculum 2000 has resulted in an unprecedented level of public attention and concern being focused on this matter. The high failure rates at AS-level, the increased drop-out between AS and A2, the continued year-on-year drop in the numbers taking AS mathematics, and the knock-on effects on university take-up of mathematics and related degrees have led to talk of 'AS chaos' (Henry, 2002) and 'maths in crisis' (Henry, 2001) in the press and beyond.[2]

During the period when the new AS and A2 mathematics courses were being introduced, I was carrying out my doctoral research into why people choose

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mathematics and the gendering of this. I collected most of my data, involving interviews with AS mathematics students and observations of their lessons, in the academic year 2001–2002, the year after these changes came into effect. Since then I have become increasingly troubled by the responses to this 'crisis' from practitioners and policy makers. This article is my attempt to begin to make sense of my concerns and to think about how to relate the detailed case studies in my research with the arenas of policy and practice. My argument is that the ways that the statistics are being constructed are leading to policies and practices that are excluding people from mathematics and so are profoundly socially unjust. Excluding educational practices and policies are not unique to mathematics (see, for example, Vincent, 2003). However, there is something particular going on with mathematics. There are powerful discourses around what mathematics is and who can learn it which function to legitimate these exclusions. More than that, these discourses naturalise these exclusions and make it very difficult to respond to figures of failure and drop-out in any other way than through pedagogic and policy strategies that exclude even more people from access to advanced mathematics. These discourses constitute mathematics as a body of absolute, non-negotiable and hierarchical knowledge. Alongside this is the discourse of mathematical ability as unchanging, natural and located within the person. These discourses are discussed widely elsewhere (see, for example, Gates, 2001; Burton, 2003); my aim here is to show how they act to *fix* our ideas about mathematics, learners of mathematics and the kinds of relationships it is possible to have between subject and learner. As I elaborate below, there is a shutting out of differences being enacted here. I want to *unfix* these and so, in this article, I also attempt to intervene in favour of an inclusive mathematics that has room for differences within it.

In the first part of this article, I trace these excluding responses. I exemplify these exclusions through focusing on two specific dimensions of difference, socio-economic class and gender. This focus is not to suggest that other differences, for example of race/ethnicity and sexuality, are not also being excluded or that, in 'reality', class and gender can ever be separated from these other dimensions (in fact, the analysis in the second part pays attention to their intersections). My argument in this article is about difference generally. However, the focus on class and gender usefully demonstrates how the fixing of difference, within mathematics education pedagogies and policies, 'adds up' in terms of specific groups of learners. In the second part of the article, I focus on detailed analysis of interviews with two students who 'dropped out' of mathematics within a year of their 'opting in' to it. My readings of their interviews start from difference, constructing, from their words, multiple motivations for doing mathematics and a range of relationships with it, attempting to open out rather than close down the play of difference. What I show here is that other ways of looking at doing mathematics make more inclusive practices imaginable and so possible. Finally, in the concluding discussion, I explore what policies and pedagogies of difference might follow from my arguments.

Transition plays three roles within this article. In this introduction, it marks out a point of 'crisis' that started me, and others, thinking and acting; in the first main part of the article (and to a lesser extent in the rest of the article), it marks out places where the excluding effects of fixing difference within mathematics education are most clearly visible; and, in the second part, it marks out spaces where learners' relationships with mathematics change and so ones that are potentially interesting to analysts, such as myself, who are exploring difference. Thus the processes of exclusion that I am exploring are not specific to the shift to post-compulsory mathematics, but this does offer a useful context in which to explore them.

Tracing structural processes of exclusion within the transition from GCSE to AS-level

Pass rates and drop-out rates

Nationally, 70% of those entered for AS-level mathematics in 2001–02 obtained a pass grade of A–E. The numbers doing A-level mathematics were 8% lower in 2002, 17% in 2003, 18% in 2004, 14% in 2005 and 9% in 2006 than the numbers entered for AS in the previous years (Government Statistical Service, 2003, 2004; Department for Education and Skills [DfES], 2005, 2006, 2007). However, these figures are difficult to read. Not all of these students will have 'dropped out' of mathematics. Some will never have intended to take the A2 course (students generally do four subjects in their first year and only three in their second year), some will be resitting their AS-level mathematics, and others will have left full-time education rather than just leaving mathematics. Additionally the AS and A-level figures contain a large number of students who are resitting rather than 'progressing'. Having said that, these statistics still look bad and compare unfavourably with those for other subjects. One effect of the discourses about the nature of mathematical knowledge mentioned above is that numbers become reified and produce the reality that they claim to describe. However, there are always other numbers and other stories. In this section I raise questions about these statistics and how they are read and acted upon.

The low pass rate at AS-level was partly reflected in the results obtained in my three London research sites, which I have called Grafton School, Westerburg Sixth Form College and Sunnydale Further Education (FE) College. Overall they did better than nationally with a pass rate of 78%. However, as Table 1 shows, these institutions showed a huge variation in their results, with pass rates of 29%, 86% and 55% respectively.

Table 1. AS and A-level mathematics results from case study schools

	AS level grade							A level grade						
	A	B	C	D	E	U	Pass rate (%)	A	B	C	D	E	U	Pass rate (%)
Grafton	3	0	1	0	2	15	29	3	1	0	0	0	2	67
Westerburg	41	33	42	25	14	25	86	63	51	17	25	9	2	99
Sunnydale	1	1	0	3	6	9	55	0	2	2	1	0	0	100

These differences show a clear correlation with the socio-economic class composition of their intakes. Grafton is an ethnically diverse, largely working-class 11–18 comprehensive school. Sunnydale is a large FE college, within walking distance of Grafton, and catering mainly for mature students doing part-time and/or vocational courses. The college was inspected during the research period, and the report (like that for Grafton) describes the local area as 'deprived', citing as evidence:

> Unemployment in the area is 11.7%, which is about three times higher than the average for Greater London … In 2000, only 34.8% of Year 11 students from [local] schools gained five or more General Certificate of Secondary Education (GCSE) grades at C or above, compared with 49.2% nationally.

In contrast, Westerburg is a highly academic college with an ethnically diverse, but largely middle-class, intake over an hour's underground train journey from the other two. Westerburg has two entry policies. Although oversubscribed, it guarantees places to members of local partner schools and allocates the remaining (majority of the) places competitively. Its curriculum is largely academic, although some vocational courses cater for the less qualified partner school entrants. Its entry to AS-levels is thus highly selective. The differences in results are striking and I will return to the issue of socio-economic class later.

While the lack of information on socio-economic class and attainment in the media means that there is virtually no discussion about the relationship between them, the problem is different with gender. There is no shortage of news items on gender and attainment, but here it is the selective nature of the information that is available which acts to control the kind of stories told. Triumphalist stories of girls' achievements dominate. These ignore that, while few differences remain between boys' and girls' national mathematics examination results, there are still significant gender differences in the levels of participation in post-compulsory mathematics. National statistics suggest that the introduction of the AS-level has exacerbated the drop-out of women and girls from mathematics since they are disproportionately leaving mathematics in the new transition point between the AS and the A2 course. In 2001, female drop-out (as measured by the difference between the A2 entry figures for 2002 and the AS level figures for 2001) was 14% compared to 4% for males; in 2002, the figures were 23% and 13% respectively (Government Statistical Service, 2004, personal communication); in 2003, they were 23% and 14%; in 2004, 18% and 11%; and in 2005, 13% and 7% (Government Statistical Service, 2002, 2003, 2004, personal communication; DfES, 2005, 2006, 2007). This represents continuity with earlier patterns, for subject choice has long been gender polarised. Kitchen (1999) investigated the changing patterns of A-level mathematics entry, performance and transition to higher education (up to 1995). She highlights the missing girls who were qualified to do mathematics but chose not to continue beyond GCSE.

Here I would argue that discourses about the absolute, non-negotiable nature of mathematical knowledge legitimate the absence of discussions on gender and socio-economic class because such knowledge is constructed as neutral (Burton, 1995; Dowling, 1998). Classed and gendered differences in attainment and participation in mathematics are then attributed to individual differences through discourses of 'free choice' and 'natural ability' (see below). The il/logic runs something like this: not everyone can do mathematics and so some casualties are to be expected, but those who do fail do so for individual not social reasons. Thus the processes through which people are excluded from having access to mathematics are constructed as an inevitable consequence of the nature of the subject itself. This is an example of the ways that what it means to be a learner of mathematics are fixed so as to systematically exclude certain groups; as a result, the range of differences within the learners in our classrooms is ever-narrowing.

As I have said, the current statistics demonstrate continuities with earlier patterns; the transition from GCSE to A-level mathematics has always been difficult. As well as gender, Kitchen's research focused on the effects of the change from O-level[3] to GCSE on A-level mathematics. Many schools and colleges have run bridging classes for students starting with experience only of GCSE Intermediate level[4] material, while the innovative School Mathematics Project (SMP) A-level course was designed with an aim to ease this transition (Dolan & Everton, 1994). These continuities are lost in the talk of chaos and crisis. I would argue that changes in assessment such as the switch to GCSE and the switch to AS/A2 produce 'crises' because the problems with post-compulsory mathematics become visible. The introduction of a new system means that teachers have not yet worked out how to identify which students they can 'get through' (that is, those they think will pass) and determine ways of redirecting those they cannot, before the official audit date or, failing that, at least before exam entry lists are compiled. This interpretation is supported by the way the AS pass rate for 2002 went up to 76% and it has stood at around 80% ever since although there have been no significant changes to the curriculum as yet (Government Statistical Service, 2003, 2004; DfES, 2005, 2006, 2007). Thus it is important to look at how teachers adapt to and accommodate a new system.

Responses to the 'crisis'

I do not know of any research specifically relating to how schools and colleges are responding to the problems. However, the trend is clearly towards making mathematics more exclusive. In the media, it has been suggested that a B-grade at GCSE is required for progression to AS-level mathematics (Hayes, 2002). As far as my research sites go the situation was as follows.

- This policy was already in place at Westerburg, where only in special circumstances were students with a GCSE grade C allowed onto the AS course. In fact, one of the teachers I observed told me that 'most of the Bs fall by the wayside', perhaps advocating raising the entry criteria still further.
- When I started my research, Grafton allowed students with a grade C onto the course but, following disappointing results, adopted the B-grade entry policy starting in 2002–2003.
- Sunnydale staff had a somewhat fatalistic attitude to their results. When I returned in September 2002 to collect the results they had not looked at the

grades for those continuing to the A2 course and joked that, in future, they should raise the entry requirements and only let people who have already passed A-level onto the AS course.

With Steward and Nardi (2002, p. 7), I want to argue against such shifts:

> The challenge facing maths education today is how to increase the number of students taking A-level maths—we are not doing ourselves any favours labelling pupils at an ever-decreasing age. While most schools will allow intermediate GCSE tier candidates to enrol onto A-level courses the messages sent out to these students are clear: namely, that they will find A-level mathematics hard and that they themselves will have to fill the gaps that would have been covered in higher tier courses.

As this quote demonstrates, it is not only through entry requirements that we send out messages about who should or should not have access to the social power of mathematics (see also Nardi & Steward, 2003). Organisational practices, such as setting and tiered entry, teachers' classroom strategies, and images of mathematics and mathematicians within the media, carry the message that mathematics is not for everyone by reinforcing notions of 'natural ability'. For example, Mrs Sawyer, one of the teachers whom I observed at Westerburg, drew on two discourses to explain attainment differences between the 16 students in her class: 'lack of preparation' was used to explain how some were doing less well, and 'natural ability' was used to explain how some were doing better. Although not explicitly invoked to explain failure, the use of a discourse of 'natural ability' to explain success necessarily carries with it the implication that lack of 'natural ability' contributes to lack of success (see Mendick, 2002).

These discourses often contain comparisons between mathematics and other subjects. These may be implicit, as when mathematics is the only subject that teaches students in 'ability' groupings or is the only subject that requires a B grade for entry onto the AS course. This sign, which was pinned to the notice board in the foyer between the mathematics classrooms at Westerburg, makes the comparisons explicit:

> MATHS IS HARD!
>
> Independent research shows that Mathematics is the most challenging subject at A-level. Nationally, last year's AS results in maths were far worse than any other subject.
>
> If you don't really enjoy Maths and if you're not genuinely good at it, don't do it! Two years of struggling and constantly being 'stuck' is not an experience we would wish on anyone.
>
> Success at A-level Mathematics usually depends on:
>
> **Positive attitudes.** Do you enjoy solving problems? Do you *like* Maths?
>
> **Persistence.** Do you give up easily and ask for help? Or do you prefer to get the answer for yourself?
>
> **Independence.** Do you need spoon-feeding every step of the way? Can you learn it by yourself?

Although the Westerburg teachers did a lot to support learners, and I am sure that this sign was put up with the best of intentions, a student could not be blamed for gaining the impression that some subjects, other than mathematics, would be recommended for those who 'give up easily' and 'need spoon-feeding every step of the way'. Interestingly the habit of mathematics teachers to break the curriculum down into bite-sized portions (Burton, 1994) could be argued to exhibit spoon-feeding tendencies. Signs such as these act as very effective 'filters', allowing through only those young people who, after reading them, remain willing and able to attempt the subject.

All of this feeds the stories that mathematics education is not for all and that we should not expect it to be. The ways in which the social divisions of socio-economic class and gender influence judgements about who is and who is not able to do mathematics, cannot be part of this debate because this would imply that 'ability' is socially constructed rather than natural. However, there is ample evidence for how very socially constructed mathematical ability is.

- As regards socio-economic class, Morgan (1998) has demonstrated how certain aspects of middle-class 'cultural capital' are commonly taken as signifiers of mathematical maturity and 'ability'. Additionally there is a growing body of evidence that ability grouping within mathematics and decisions about tiered entry at GCSE are classed (for example: Boaler, 1997; Gillborn & Youdell, 2001; Wiliam & Bartholomew, 2004).
- As regards gender, Walkerdine's (1990, 1997, 1998) work demonstrates that femininity is discursively produced 'as antithetical to masculine rationality to such an extent' (1990, p. 134) that women and girls can neither be ascribed ability nor ascribe it to themselves without a struggle. For example, she shows how girls' better performance than boys' in mathematics is rendered invisible by discourses that construct it as 'rote-learning' and 'rule-following', in contrast to boys' inferior performances which are valorised through their construction as resulting from 'real understanding'. More recent work by myself (Mendick, 2005), writing on the gendering of self-identification as 'good at maths', and by Jones and Myhill (2004), writing on teachers' constructions of underachievement, demonstrate the continued relevance of Walkerdine's arguments for understanding the gendering of mathematics.

There are some less publicised voices calling for a more inclusive mathematics. For example, Porkess (2001) has suggested making the assumed knowledge (covered in higher but not intermediate tier GCSE) testable at AS-level, cutting down the content, and changing the funding arrangements so as to encourage people to take more than a year to achieve AS mathematics. However, even here the argument that the content needs to be reduced is dangerously close to saying that the subject needs to be dumbed-down in order to be accessible to currently excluded groups. This is an argument that ultimately reinforces the same exclusivity it is trying to address since by constructing a need to adapt mathematics to make it suitable for specific groups of learners you simultaneously attach intellectual inferiority to their difference.

There is a vicious cycle operating here, evident in this quotation from the then Chair of the Mathematical Association Teaching Committee, writing in the *Times Educational Supplement*:

> Last summer 38.9 per cent of students completing A-level maths achieved grade A, despite the fact that the AS/A level course has one of the highest failure and drop-out rates. With such a high proportion achieving the top grade in the subject, it is vital that the most able can access a more demanding qualification, to stretch and inspire them. (Stripp, 2004)

However, it seems more likely to me that the high proportion of grade As at A-level mathematics was obtained *because* of the failure and drop-out rates at AS level, not *despite* these. The patterns in proportions of those gaining A and U grades showed a dramatic shift in 2002, the first year of the new A2 courses. The roughly 30% increase in the proportion of A grades and 50% decrease in the proportion of U grades, shown in Figure 1 (DfES, 2005, 2006, 2007; sources: Government Statistical Service, 1995; Government Statistical Service, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004), were unprecedented.

The story so far …

I have argued above that mathematics has a history of systematically excluding differences so that certain groups have less opportunity and desire for participation in the subject, are judged to have less ability at it, and garner less success within it. I have made this argument by focusing on two specific dimensions of difference, gender and socio-economic class. I have further argued that recent developments provoked by the ‘crisis’ in mathematics education that followed from the introduction of AS-levels have resulted in an intensification of these processes, with mathematics becoming more restrictive, and with even less room for difference. Finally I have shown how these excluding processes are legitimating measures that will lead to further exclusivity.

This matters for many reasons. Many in the UK have raised concerns about the levels of numeracy skills in the general population and about whether we have sufficient people with the mathematical skills needed to service our economy (Smith, 2004). However, more than this, it matters because mathematics is a powerful

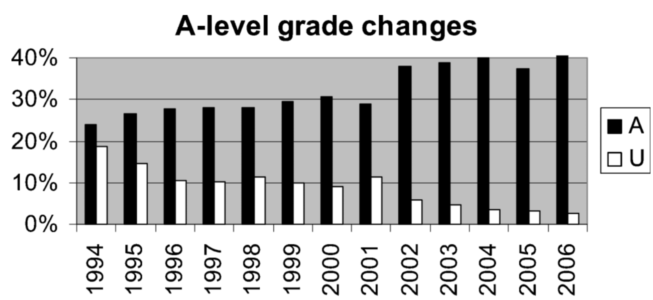

Figure 1. The proportion of A and U grades at A-level mathematics: 1994–2006

subject; it acts as a critical filter into a wide range of high-status and financially lucrative fields and success at the subject carries high social status (Byrne, 1993). Thus how mathematical skills and the qualifications that serve as evidence for the possession of these skills (and that are often used as a proxy for a measure of general intelligence) are distributed is a social justice issue. Thus there is a need to explore ways of intervening in the current debates around access to advanced mathematics. This is the focus of the second part of the article.

Intervening in the debates

As I have said, there seems to be a vicious cycle going on and it is difficult to know how to go about intervening in this. Below, I offer two case studies of Jonathan and Maryam's transitions to post-compulsory mathematics in order to develop a more productive approach to dealing with difference within mathematics education. The practices of exclusion that I have been looking at so far with reference to gender and socio-economic class operate much more broadly than that. Further, it is well-documented that a specific focus on one aspect of inequality can lead to exclusions of other others (see, for example, feminist work by working-class women, women of colour, lesbians and women with disabilities, such as, Lorde, 1984). Thus, I am working here with difference in its broadest sense; gender and class are part of this but so too are race/ethnicity, sexuality and much more. These dimensions intersect with each other in multiple and messy ways.

Methodology

Jonathan and Maryam were both in the first year of AS-mathematics. They were selected from the 43 participants whom I interviewed in 2002 for my doctoral study. Both were in the first term of their AS-mathematics course when I spoke to them and had a history of success at mathematics, having secured A grades in the examinations they had taken in the previous summer. At the start of the AS-level course mathematics was their favourite subject; by the end of the year Maryam could not wait to leave and Jonathan had already gone. Theirs are stories of loss. Although their narratives were not written with this article in mind, it seemed to me that they offered a way of intervening into the debates I am discussing. Thus I tell their stories here in order to generate new understandings of what people are doing when they are learning mathematics and of what happens in transitions into AS mathematics, and in the hope, through these, of provoking new ways of engaging with curriculum, assessment and pedagogy within mathematics education. Below I briefly outline my methodology (a more detailed discussion of this can be found in Mendick, 2003).

In their interviews, I asked participants to describe a typical mathematics lesson, about what they most and least enjoyed about the subject, to compare mathematics with other subjects, about how they learn best, about what other people not doing mathematics think of the subject, about their educational choices, and about their feelings on gender. Interviews lasted between 15 minutes and an hour and were carried out with individuals or with small groups of two or three according to the wishes of my participants.

In the analysis my focus was on the 'identity' of my participants. I see identity as something that is continually being made and remade in and through our words and actions (see the analyses in, among others, Epstein & Johnson, 1998; Youdell, 2003). I constructed a narrative for each participant that draws out the ways in which what they told me about their choice of mathematics and their relationship with it functioned as 'identity work', as part of the resources they draw on to tell me and others about what they are and are not like. My readings were psychoanalytic for I see 'identity work' not simply as a conscious series of choices but as riddled with unconscious processes, such as desires, anxieties, defences and phantasies (Hollway & Jefferson, 2000; Walkerdine, *et al.*, 2001).

In finding ways to understand the specific psychic processes that operate within our relationships with academic subjects I have drawn on the work of Shaw (1995). She argues that the shift from primary to secondary school (at age 11) marks a shift from a teacher-based to a subject-based arrangement of learning that requires young people to reorganise their sense of self:

> As teaching moves away from being organized around a whole person and towards the more specialized and fragmented notion of the subject, these subjects are, at some level, required to substitute for the person (the teacher) in framing the pupils' sense of self. (Shaw, 1995, p. 103)

Shaw (1995) argues that as education becomes an increasingly anxiety-filled activity we increasingly rely on choosing subjects with which we feel comfortable as a defence against anxiety. We relate to subjects as we do to people. We expect things from them, we get used to them, are upset when they change, and we feel let down by them. Subjects are a source of comfort or, if the wrong choice is made, of distress, anxiety and even terror (for example, see the experiences of mathematics learners, in Buxton, 1981; Early, 1992). They function like people, 'they have to be related to and identified with … one has to "get on" with' (Shaw, 1995, p. 113) them. And, like people, academic disciplines have different 'personalities':

> This means that educational choices such as choosing, specializing and dropping a subject may bear less relation to rational or future-oriented factors (anticipated career, for example) and more to past feelings about parents, siblings, and teachers and the relationships with all these people that have become embodied in the subjects. (p. 107)

Finally, I clarify my epistemological position. Although both the stories that follow are firmly grounded in the data, they are not attempts to uncover the 'truth' about how either learner 'really' feels. All stories, whatever claims they make to authenticity, are based on certain assumptions and are designed for particular purposes; the best we can do is to be explicit about these. Mine are designed as strategic interventions into the debates discussed in the first part of the article for the purposes of promoting social justice. Particularly relevant here is my use of psychoanalysis, which is often associated with authentic selves, being viewed as discovering what is really going on. I want simply to suggest that a discussion of unconscious processes provides a useful way of reading students' accounts of their experiences of learning mathematics: useful because in this way we can disrupt the desires, sometimes conscious and sometimes unconscious, of practitioners, explored earlier in this article, to close down mathematics still further. I tell Jonathan and Maryam's stories at length and present them in a style more commonly associated with novels than with academic papers because I feel that the strength of the desires that I am attempting to disrupt requires this kind of approach.

Jonathan's story

At the time of the interview, Jonathan is living with his mother who works as a 'specialist nurse.' He has spent the last two years in Uganda, 'my country of origin,' interrupting his GCSE work and taking O-levels instead. He is now at Sunnydale studying A-levels in art, mathematics and physics. In his story, I begin by discussing what Jonathan tells me when I ask him how he feels about mathematics and I then read these feelings as part of the work on his self-in-relation that he does through mathematics.

It is evident from Jonathan's interview that he takes pleasure in mathematics. During his O-level 'I enjoyed all the topics that I studied,' but he most enjoyed the work on trigonometry, 'I found it easy and it was a challenge to me … Trigonometry's just really about the manipulation of data, which you already have and that's something which I like to do so it's something which appealed to me. That's why I think I found it easy because it did appeal to me.' The idea of applying material that you already have is central to how Jonathan characterises mathematics and to the pleasure that he gets from the subject. He first introduces this theme, in terms of the manipulation of known and unchangeable rules, when I ask him whether he thinks that mathematics is about learning rules or understanding why rules work: 'I see mathematics as, as learning the rules and then applying the rules. And that's the way I see mathematics. That's why, um, I think that's one of the reasons why I do like mathematics more than other subjects because … it is about applying stuff that you already know.'

Jonathan uses this idea to compare mathematics with other subjects. In his opinion mathematics is similar to physics because the latter 'is also about learning rules and applying rules.' However mathematics is different from the humanities, 'there's subjects like history and geography and that's just about memorising what you're told. And I don't really like that, I like, um, technical subjects where you have to really think and apply.' Art too, which 'is about learning [the] rules of drawing and stuff like that and then learning how to break the rules,' is very different from mathematics where the rules are fixed. Jonathan returns to this idea when he is explaining to me why art is taught in a different way from his other two subjects: 'Art is a totally different subject from mathematics. The rules which are applied in art are, are not mathematical rules. Well some of them are. And, but generally they're not mathematical rules. They're rules on perspective and stuff like that. So it is taught in a different manner.'

As well as arguing that different teaching styles are appropriate to different subjects, Jonathan tells me that he adopts a distinctive learning style for mathematics which 'is the only [subject] which I really like working by myself in.' In mathematics, 'I really tend to work individually but I don't have a problem sharing my work with other people … But, I really prefer to work on my own.' He prefers this way of working in mathematics because 'I can concentrate fully on what I am doing, I can focus my mind. 'Cos if I'm working with other people my mind is always distracted by other little things what people are saying and what's going on. But when I'm on my own it's just like, it's just me and the work and there's nothing else left.' He again draws on discourses around applying rules to explain why he likes working in groups for physics but not for mathematics: 'because physics is, is like, um, you're given a statement or a set of rules and you're given a situation and you have to see how those rules work within that situation. And it's like there's many ways that the rules can work, so it's like there's, there's lots of room for discussion and everybody can have like a different idea. Some ideas do make a lot of sense and it's like you, you might think it's working, it works only in [one] way, but then someone else might come along with something else and you can see, yeah that, that also works. And it's just like you've got all these different rules that work that can be applied to the same situation.' Here Jonathan is arguing from his experiences that mathematics is learnt and taught in different ways from other subjects not just because there is only one right answer but also because there is only one right method.

Jonathan seems clear and confident about what he is doing throughout our interview. One example of this is his approach to answering questions in class: 'It depends really on the topic, if, if I'm really sure about the topic then yeah … I'm up for being asked questions and I enjoy it. But, if I'm not really sure then I'm just scared that I'm gonna be embarrassed if I get a wrong question. Then … if the teacher's asking people to, to give answers in front of everyone else, I'll usually just hold back and let other people answer. So if my answer's correct then I'm just happy in myself but if it's, if it wasn't correct then … I'm just glad that I didn't give my answer to the class.' Another example is his sense of ownership over his choice to engage with mathematics at O-level compared to GCSE: 'When I did GCSE mathematics it's just like I wasn't really interested in it, I just did it because my parents wanted me to do mathematics. They wanted me to get good grades. But I wasn't really interested in it.'

However, Jonathan left Sunnydale before taking the first A-level module in January. In what follows I look for an answer as to why he dropped out so early. I argue that O-level mathematics, for Jonathan, was a way of reworking his relationships with adults, notably family members and teachers, and shifting from a dependent position relative to them to a more equal and autonomous one, and that this kind of work was no longer possible in his Sunnydale mathematics class. This is a shift that is evident in the last quote, a move from doing mathematics for his parents to doing it for himself.

Jonathan's time spent in Uganda is central to how he constructs this shift in the space of the interview. The reasons for his move to Africa were 'personal [ones] between me and my mum. My mum and myself were having some problems, and she just decided it'd be better for me if we spent some time apart.' Going to Africa thus marked a move away from parental authority towards a different relationship with his cousin. Jonathan made the subject choices he did because of his interest in pursuing academic studies and a career in architecture. His initial explanation as to what appeals to him about architecture is that 'it's just the creative side of me just designing buildings and making things that look nice.' However, when I ask when he first wanted to be an architect he speaks of an additional motivation: 'I think that was around '99, something like that. 'Cos when I went to Africa I went to live with my cousin, he's an architect. So I was staying with him and it's just like he influenced me.'

Parallel to Jonathan's changing relationships with his family, his move to Africa and experience of different teaching styles marked a change in student/teacher relationships. Jonathan feels that there were real differences between the teaching and learning styles used and encouraged within his O-level mathematics lessons in Uganda and those associated with his GCSE mathematics lessons in England. While he frames this as a contrast between GCSE on the one hand and O-level on the other, I read it as a contrast between the teaching styles in the two countries with no necessary connection to the examinations. He describes a typical O-level mathematics lesson in Uganda, 'you go into class. The teacher would come in. He would tell us what we're gonna study in the lesson and, um, [he pauses] give us a couple of examples on the board, just give us the basics of what we're supposed to learn and then he'll give us a couple of questions to try out.' The way the teacher presented only the basics of each topic meant that students were expected to display a great deal of independence in their study habits. Jonathan contrasts this with the dependent attitudes that he saw cultivated in his GCSE classes: 'O-level maths is, is really about, um, studying by yourself, learning the things by yourself, and GCSE maths is just really like studying in the class. The teacher tells you something and you just write it down. And that's what you're supposed to remember. But O-level maths is like: you're told something and then you're told to go and do your own research on it and find out some stuff about it … I enjoyed the way I was taught the O-level maths more because it focused me more.' This teaching pattern made it possible for Jonathan to occupy a new and more responsible position relative to his teachers and to mathematics.

Jonathan thinks that his current teaching is more like that of the O-level than it is like that of the GCSE. However, when I ask him to compare the A-level and the O-level he comments: 'The only difference that I can really say is just that, um, the A-level maths does not go into as much detail as the O-level maths and the subjects covered are not as wide as the O-level maths syllabus.' He is happier with the way that he is being taught art than with the way that he is being taught mathematics: ''cos the [art] teacher does encourage me to do the work in the class. Meanwhile … with mathematics I'm just used to doing the work on my own so in class I don't really pay attention I'm just like racing ahead doing the work and then if I get stuck, that's when I, I call the teacher over.' Thus, although, as I discussed earlier, elsewhere in the interview Jonathan explains the different teaching styles in his A-level mathematics and art lessons in terms of the nature of the subjects, what he is saying here appears to contradict this. Here it seems like his O-level mathematics lessons have more in common with his A-level art lessons than with his A-level mathematics lessons. This suggests that the space that was there for working on autonomy is lost and this is perhaps why he left the course.

Maryam's story is also about the loss of possibilities for particular kinds of identity work accompanying her transition from compulsory to post-compulsory mathematics.

Maryam's story

Maryam is 'half English, half Egyptian, my dad's Egyptian and my mum's English.' When I interview her, her mum is working as a classroom assistant in Maryam's old primary school, while her dad owns two businesses. She is studying for AS-levels in economics, mathematics, psychology and sociology at Westerburg. Unlike Jonathan, who chooses to be interviewed individually, she is interviewed with her friends, Imran who is working class and Bengali, and AJ, who is middle class and Indian. Of the three Maryam displays the strongest identification with mathematics in the interview. When I ask about her subject choices she explains, 'maths was my first, [the] first one that I knew definitely that I was doing [was] maths, but the others I didn't know if I was gonna do them or not. It took me ages to decide. Maths because I do love maths … I just think it's, it's like everyone has a subject that they, not even that they like, it's just that, not hmm, not good at either, it's just' she pauses. 'What about your other subjects?' AJ interrupts.

Maryam continues her previous train of thought: 'it's just natural.'

'Is it something you feel comfortable,' I begin to ask.

'Yes, it's something I feel comfortable with. Maths was my subject. And everyone knew that. I just love maths, sad, but true!'

The assurance with which she speaks about her choice of mathematics contrasts with the doubt in her discussion of her other choices. She is unsure of what career she wants to pursue. She has abandoned an earlier plan to be a primary school teacher because she now considers teaching 'the most stressful job.' She expresses some interest in business and in law, and then adds, 'I wanted to be a psychiatrist at one point 'cos they make enough money, but I'm still not sure.' The uncertainty is also clear in the reasons Maryam gives for selecting her other subjects: 'I picked economics because I done business GNVQ in year 11 (aged 15–16) but I didn't want to do business studies at AS, but I wanted to do something similar;' 'I just think [psychology's] one of the best subjects you can do and it's really popular here … and we've never been taught anything like it in GCSE;' 'if you learn about sociology you learn about … why people are doing that and you live in a society so you need to know these things, 'cos we never got taught that at GCSE either.' So mathematics is Maryam's only continuity between her studies at GCSE and at AS-level.

However, her relationship with mathematics is complex. She 'loves' mathematics but also 'think[s] that it's generally not that interesting, like to, even to me, it's generally not really that interesting, but it's just, but I enjoy it, if you get me, I know that seems to contradict myself.' There are two ways of making sense of this apparent contradiction. The first is to look at the context. This comment comes immediately after Maryam explains that mathematics 'doesn't show your creative side at all, it just shows … your understanding and how to apply things.' This makes it different from her other subjects: 'With psychology it's more like activity work and group work, and sociology as well, and maths, you can't really do that. You've got to work as an individual. There are some times when you can like look at new topics and research them in groups or something like that, the majority of the time you're working alone and that's just the way it's got to be. 'Cos you've got to have your own understanding.' Maryam summarises what characterises mathematics in distinction from her other subjects: 'It's either right or wrong. There's no two ways about it.' So the 'contradiction' arises because mathematics is both Maryam's favourite of the subjects that she is doing and the one that does not fit with her pattern of preferences for ways of working and subject matter that generally stress the creative and the collaborative.

Second, it is clear in Maryam's story that what she is enjoying in doing mathematics is not the subject matter itself. So the 'contradiction' in her account can be understood as arising because of how difficult it is to talk about enjoying mathematics for any other reasons. I speak about what it is that Maryam is enjoying in the rest of this story. I look at the pleasure that Maryam found in GCSE mathematics and at why she no longer finds this in AS-level mathematics. Up to now mathematics has been a place of safety for Maryam, a comfort blanket, and this is disrupted by her experiences of AS-level. In my study, there are other stories of loss in participants' accounts of their relationships with mathematics (such as Jonathan's), but Maryam's was the most striking because of the dramatic nature of the change. In a few months she went from a lifelong 'love' of mathematics to a position in which she is eagerly awaiting being able to drop it after the first year modules.

Maryam's memories of GCSE mathematics are dominated by her final year when, as a result of the group being behind schedule, her teacher imposed an unusual pattern of teaching and learning on the class. 'The class was split up into two [mentors and mentees] and then the mentor would have to sit next to their mentee and then they'd have to make sure that they did their homework and everything, and like that they're understanding the work. And then the mentors would go to extra class on Saturday mornings and we would learn the topic and we would have to teach it to the class on Monday.' It is clear within Maryam's discussion of this scheme that she gained a lot of pleasure from it. She says that she was 'flattered' to be chosen since 'our teacher just picked the more cleverer people to be mentors.' Being a mentor was a powerful position for Maryam and this is evident in her talk about what she has enjoyed most about mathematics: 'You know, I was saying like how we used to get up and teach the class. I, I always really enjoyed it, 'cos out of English, maths and science, anyway, my best subject was maths, and it's always been my best subject … and I used to be the best at explaining to the class, I'm not being bigheaded [to Imran and AJ who are being sarcastic] but I was, I was, you can even ask Shakilah and everyone used to call me, like, 'second teacher' and everyone used to say to our teacher how I'm gonna take her job … And I really enjoyed it 'cos everyone understood.' Maryam's role as a 'sub-teacher' (Walkerdine, 1998) gave her access to a power that few students have within mathematics classrooms. She took pleasure in this and in the caring aspect of her role, making sure that 'everyone understood' (Gender and Lifelong Learning Research Group, 2003). Her use of the word 'always' here suggests that this powerful position was consistent with ones she had occupied in her previous experiences of learning mathematics.

The contrasts, between Maryam's feelings at GCSE and her feelings at AS-level, are stark. When Imran mimics her saying 'I'm the best' her response succinctly captures this change: 'I am! I used to be, sorry.' The sense of loss that she is feeling, even after only three weeks of the course, is evident in this extract: 'I used to be the, like proper, like the best. I'm not being funny, I used to be the best in my class and now I've come here … I was the closest to an A* out of everyone. But I didn't get it by a few marks.' At Westerburg she feels stupid: 'it's like, I'm at like the bottom of the class.' I now look at what Maryam says about her new group in order to explain this change.

Maryam begins talking about how she feels in her AS class when I ask about whether the gendered composition of the group bothers her: 'It does actually, because like most of the guys there are like really, really clever and I think if there was more girls to balance it out, then it would be … less tense 'cos at the moment it's quite tense 'cos all the boys, especially boys they like to compete with each other, and I think that … most of the people on the back row, anyway, are competing with each other and like, which makes them go faster, which makes you want to go faster because you feel like you're behind.' Maryam projects both 'ability' and competitive spirit (and later in the interview 'nerdiness') onto the boys in the back row. This is a process that does not seem to be based on the actual 'abilities' or behaviours of the boys in question but one that is made possible by, among other things, the gendered discourses of rationality and genius (see Mendick, 2005).

This has negative effects on Maryam's ideas about her own 'ability' and confidence at mathematics. 'It makes you feel a bit like: "well, why don't I know about this?" But it's not like you're low, it's just that they're really, really high … And if the majority of the class is understanding it better, then the class will go faster. But, but I do enjoy the maths lessons and I do think our teacher's good and I think she does like, she does go through it on the board … all the time and she's making sure that we understand. I know she knows that there are people that are high, that are faster than us and some that are slower, and she's trying to like get the balance, but still I think it's like the class is divided whether people are like on the just normal starting AS-level and some are really higher … It's quite intimidating sometimes … I feel sorry for them 'cos like, if we're, I feel bad that we're holding them back and I don't want to hold anyone back but at the same time I don't want to be left behind.'

Again Maryam is projecting feelings onto the boys in the back row. She imagines them as unhappy with her for slowing the group down. This is in contrast with her mentoring experience where her class was divided and she did not feel held back by helping others to understand but indeed identified this as what she most enjoyed about those lessons. In addition to the gendering of the current divisions, there are two important differences between the divisions in Maryam's GCSE class and those in her AS class. First, in her GCSE class Maryam was positioned on the knowing side as an authority and a helper rather than as unknowing and helpless. Second, the discursive practices surrounding the divisions are different. The motivational practices encouraged by Mrs Sawyer include her stress on working quickly, the public reading out of test marks, the active encouragement of within and between group competition, the constant talk about some members of the group being more 'naturally able' than others and some being 'badly prepared' by their schools (briefly mentioned above), and, above all, the way that everything is subsumed to the goal of the examination. These practices narrow the range of possibilities available to students to construct relationships with mathematics. These explain some of Maryam's distress and help to explain what she has lost in the transition from one mathematics environment to another.

Concluding discussion

The statistics with which I began this article are powerful not because of their power to describe reality but because of their power to produce it. I have argued that the reality they are producing is one in which mathematics, an already exclusive, narrow and closed academic field, is becoming ever more so. I demonstrated this in the first part of the article through an examination of the dimensions of socio-economic class and gender, but as the case studies in the second part show, the exclusion of differences within mathematics applies more generally.

These shifts make sense because mathematics is already constructed as narrow. This happens through two collections of interrelated discourses:

- discourses about mathematical knowledge that construct it as a collection of certain and non-negotiable, and hierarchical truths, which have nothing to do with subjective and contextual factors;
- discourses about mathematicians, based on the idea that people have mathematical ceilings and so only some people can do higher-level mathematics and that this 'ability' resides within them as if there were a maths gene and so is 'natural' rather than socially constructed.

These discourses of mathematics as a subject where answers are right or wrong and understanding must be individual are evident in Maryam's story. These stories that Maryam speaks are so powerful that they make it impossible to make sense of her GCSE classroom as a space where her understanding was collectively arrived at through the relational work done between, among others, herself and her mentee. They also make it impossible to think the impact of the emotional investment she has in being good at mathematics and being comfortable with it. However, without this we cannot understand what has gone wrong for Maryam in the shift from GCSE to

AS-level. Maryam can be understood to have left mathematics because she lost the safe space that mathematics was for her, a refuge from an anxious world, and one through which, previously, she built peer relations from a position of power. In a similar way, I argued that to understand why Jonathan left mathematics we should look at how, within O-level, he worked on his relationships with adults and took pleasure in moving to independence from his parents and teachers through mathematics. This was a possibility not open to him within his AS-level classroom.

It is difficult to think what Maryam's and Jonathan's stories mean in terms of policy and practice on curriculum, assessment and pedagogy and how to think from the micro to the macro; however, for the reasons explored in this article I think it is important to do this:

> The challenge is to relate together analytically the ad hocery of the macro with the ad hocery of the micro without losing sight of the systematic bases and effects of *ad hoc* social actions: to look for the iterations embedded within chaos. (Ball, 1994, p. 15, original emphasis)

Perhaps the struggle to make such connections between the personal and the political is as important as the outcomes of this struggle.

So, turning to the experiments in thought in this article and reflecting on my readings of Jonathan and Maryam's interviews, I am suggesting an approach that seeks to engage with the multiple and proliferating differences that exist within classrooms rather than seeking to ignore or eliminate them. I am not arguing that the mathematics classes where Maryam learnt GCSE and Jonathan O-level are in any sense better or more socially just environments than the ones where they learnt AS-level (perhaps they were but that is not my point); these environments may have worked for Maryam and Jonathan but there were doubtless many other learners who experienced exclusion from them. Instead I want to argue that different identifications with mathematics were possible in the different spaces and these impacted on Maryam and Jonathan's feelings about and success within the subject. Different spaces make different identity work possible and the main conclusion I want to draw in this article is that we need pedagogies and policies of difference that aim to create learning environments that open up the range of available identifications with mathematics. I am arguing here for pedagogies and policies of difference, not of diversity. While diversity is based on liberal notions of tolerance, difference acknowledges that conflicting ways of being do not happily co-exist in a multicultural utopia (Bhabha, 1990).

So to sum-up: we need to open mathematics up. It is not my aim here to spell out exactly what this would mean in practice but I end with some indicative ideas. Underlying them is an understanding that 'policy is not exterior to inequalities, although it may change them; it is also affected, inflected and deflected by them' (Ball, 1994, p. 17) In other words, policy and practice cannot, in any simple way, be used to solve problems of inequalities, for they are implicated in constructing those very inequalities.

Assessment significantly structures how teachers teach. At the level of assessment policy the closing in of mathematics plays out in a variety of ways. For example, there are the direct moves to restrict access to AS-level mathematics to a smaller group of people by raising the entry requirements. There are also policy shifts such as the prohibition on the use of graphics calculators in significant chunks of the AS and A2 examinations, the modularisation of AS and A-levels and the tight examination schedule, which act to restrict the activities which take place in mathematics classrooms. These commonly reduce pedagogy, as they did at Grafton, Sunnydale and Westerburg, to little more than a series of topics followed by a series of past papers, and so limit the possible ways that teachers and learners engage with the subject. Further, an over-emphasis on results also means that other ways of building relationships with mathematics are closed off. There is now far less variety of A-level syllabuses than there was 10 years ago when courses such as SMP and MEI (Mathematics in Education and History) made pedagogic use of investigative work and comprehension tasks, and assessed students via coursework and end of unit tests, marked by teachers, as well as by terminal examinations. Their starting point was that advanced mathematics courses should be accessible to anyone getting a grade C or above at GCSE; they then went about designing courses that would meet this requirement. Assessment policies of difference would again use this as a starting point for course design. Accessibility, not just to those with a variety of entry requirements but also in terms of gender, socio-economic class, race/ethnicity and so on, would be used both as starting points for course design and as ways of judging the effectiveness of particular courses. Within such an approach, mathematics becomes negotiable.

As I have said, pedagogy is significantly structured by assessment, but even within a fairly rigid system there is space to move. The arguments in this article suggest that we need pedagogies based on the principle that mathematics is many things to many people, rather than an absolute body of knowledge with which we cannot argue. These would be pedagogies that open up the range of available stories about mathematics, and those learning the subject, and make spaces for more voices to be heard over the currently dominant voice of mathematics; this involves dialogue across difference (Yuval-Davis, 1997). Noddings (1993), paying attention to the complexity of pedagogic power relations, writes usefully about the role of dialogue in politicising mathematics classrooms. Two of her strategies will give a sense of what this means. First is allowing students to work together: of course allowing this is not enough; students need to 'learn to draw each other out, build on each other's suggestions, and express their appreciation for good ideas and hard work' (Noddings, 1993, p. 156); developing group working needs to be an explicit goal, at least as important as developing mathematical skills. Second Noddings (1993, pp. 156–157) suggests asking: 'How shall we do this problem? and then … follow[ing] student contributions to their logical conclusions.' This is a radical alternative to simply asking a question in order to get the desired answer and carrying on regardless of whether it is given or not. There are many other useful approaches, including: allowing and encouraging students to talk about their emotional and relational responses to mathematics in the classroom and within assessed work (Povey, 1995) and encouraging students to develop an awareness of the unspoken assumptions in the questions they are doing and using these as the starting point for them to pose and solve new questions (Brown & Walter, 2005).

Such strategies will neither lead to everyone enjoying mathematics nor to everyone wanting to carry on with it. That's not the point. However, by creating more spaces for people to construct their relationships with mathematics they might give people like Maryam and Jonathan, and the thousands of others who do AS mathematics each year, a chance to explore what they can do with mathematics (rather than finding out what they can't do).

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Notes

1. General Certificate of Secondary Education (GCSE) examinations are taken in England and Wales at age 16+ at the end of compulsory schooling, Advanced Subsidiary (AS)-levels are taken at age 17+, and Advanced (A)-levels at age 18+ (this second year of post-compulsory examinations being referred to as A2). Although AS-levels existed before Curriculum 2000 was introduced, there was little take-up of them.
2. I first wrote this in 2004 and the pattern is not substantially different now. There was a slight and much publicised increase in the numbers taking A-level last year from 46,037 in 2005 to 49,805 in 2006 but this still fitted with the overall downward trend, since the figure for 2004 was substantially higher at 51,128 (DfES, 2005, 2006, 2007). Because of the gap between writing and publication I am pleased that I have been given an opportunity to update the figures. It is depressing how little has changed in the patterns I first explored three years ago and so how much the recent data support my arguments here.
3. Before the introduction of GCSE examinations, school leavers could take CSE (Certificate of Secondary Education) or O-level examinations at 16+. Only the latter was designed to prepare students for A-level examinations.
4. At the time of writing, GCSE mathematics can be entered at one of three different tiers—higher, intermediate and foundation—each associated with a different syllabus. The grades A*–D, B–F, and D–G are available at each level respectively. So although students can gain passing grades at both the intermediate and higher tiers, those entered for the former will have covered far fewer mathematics topics.

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